Discoveries in the Adolescent Brain

Implications for Teaching & Learning

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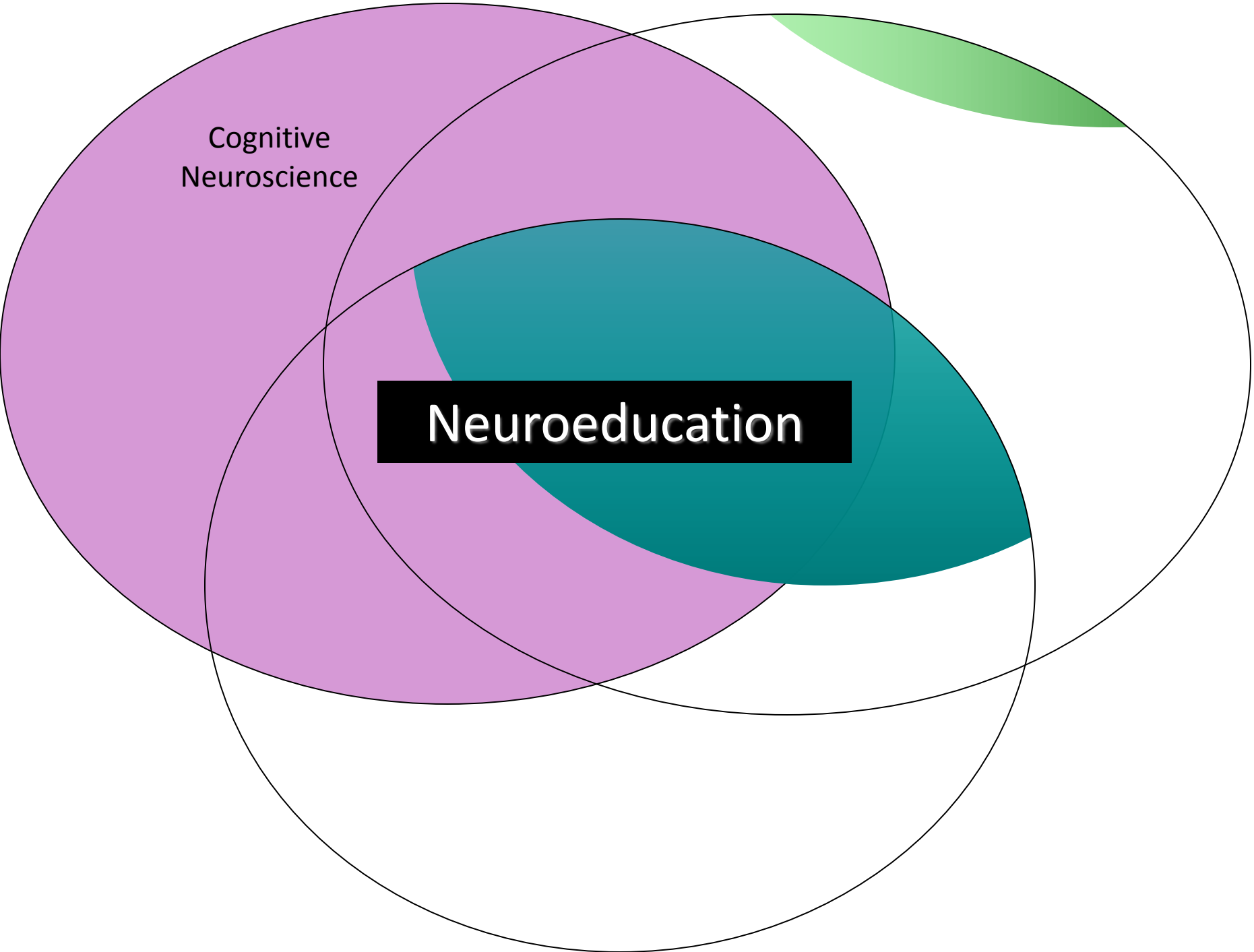
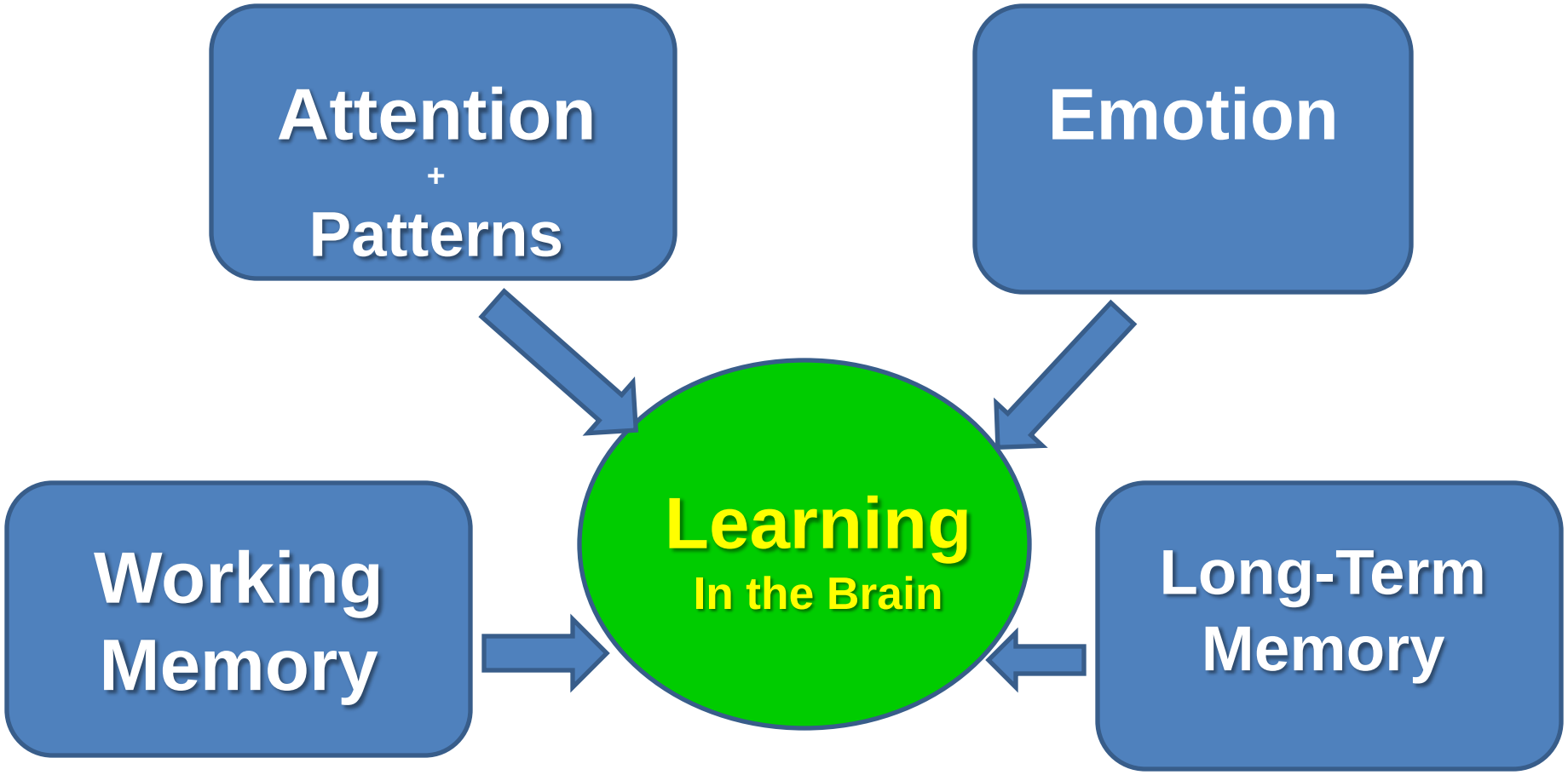
Modern Understanding Started With An Accident

Phineas Gage

The Brain is the most complex system in the universe

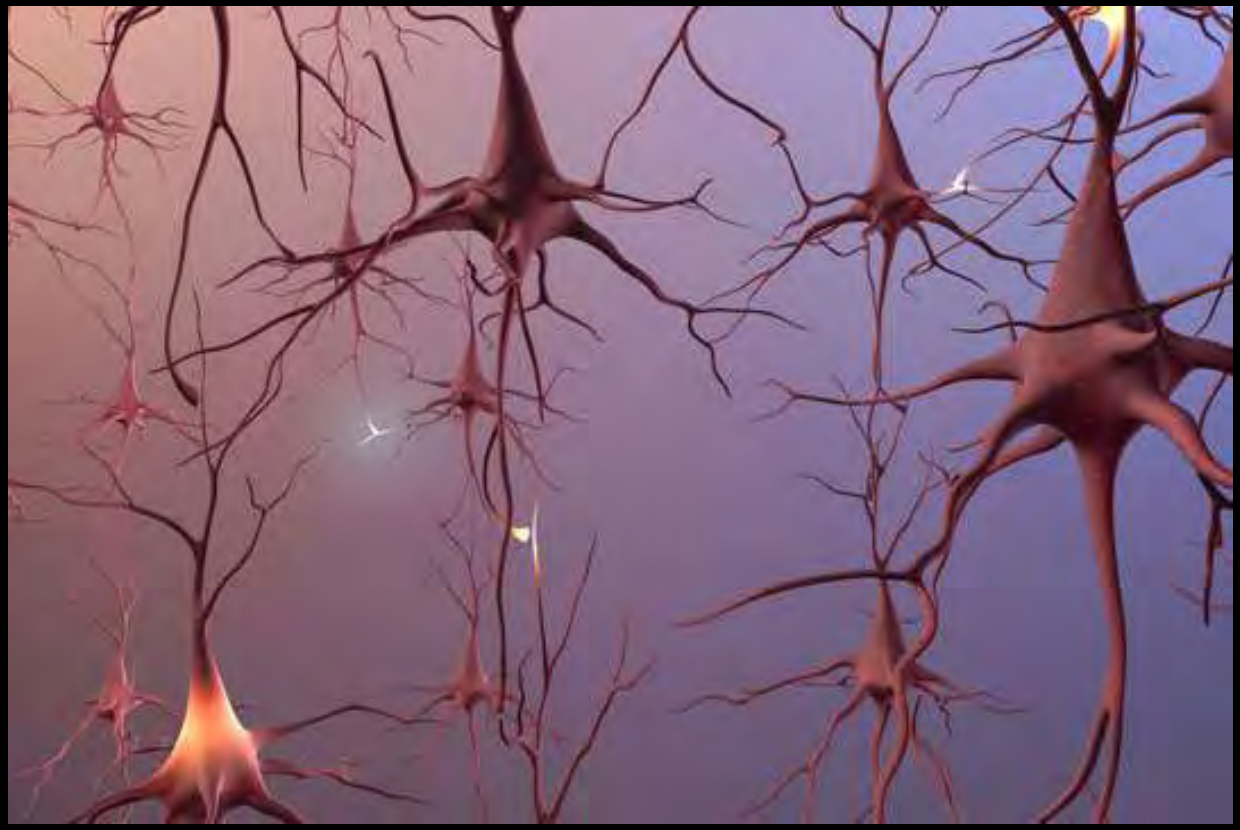

Cognitive
Neuroscience
Neuroeducation


Attention
+
Patterns
Emotion
Learning
In the Brain
Working Memory
Long-Term Memory

The Context:

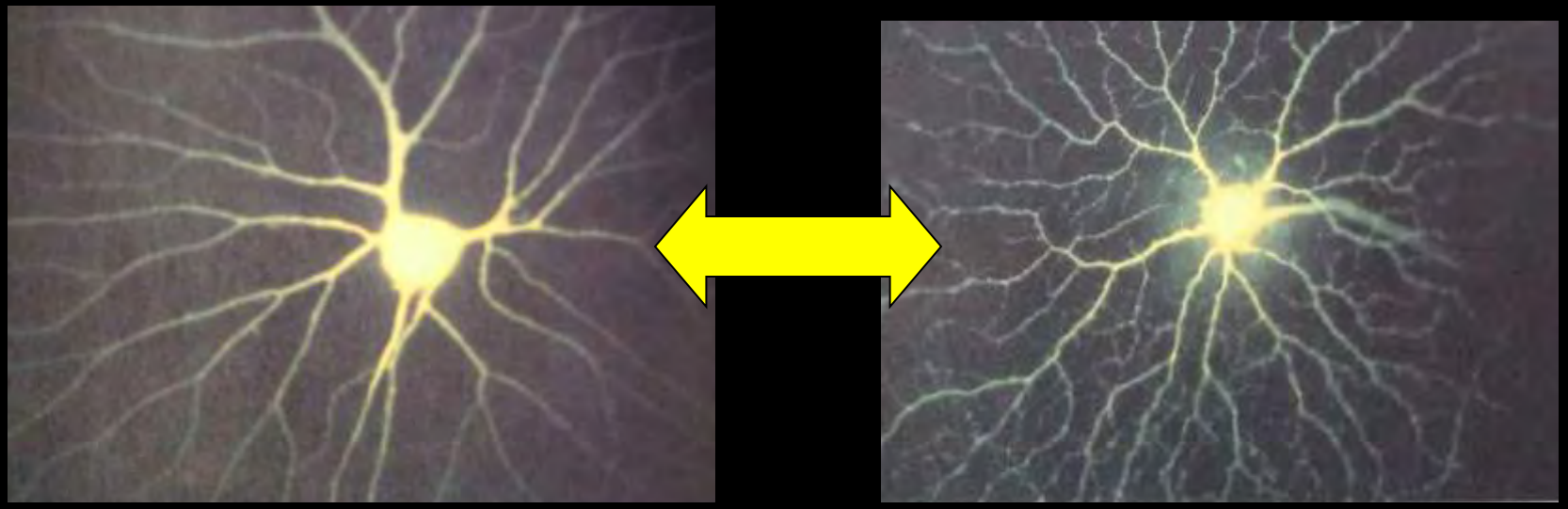
How The Brain Grows

Brain Grows at the Cell Level

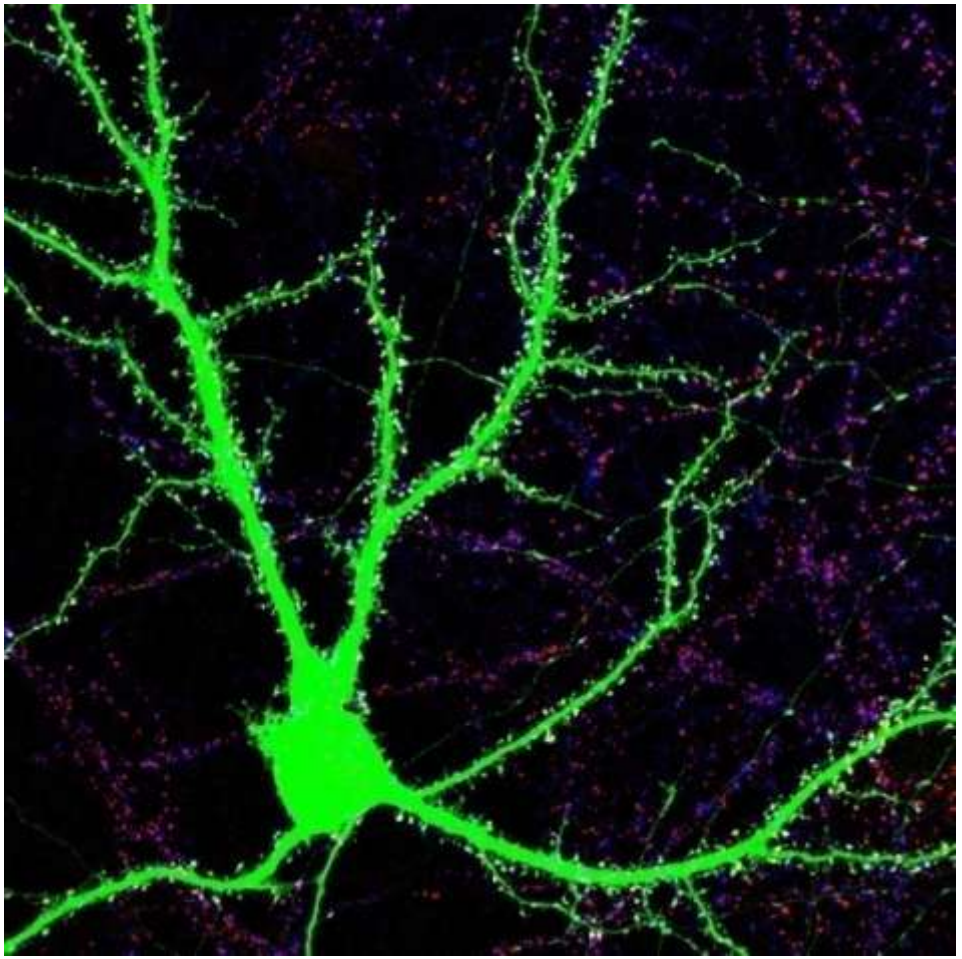


Neurons Grow More Connections

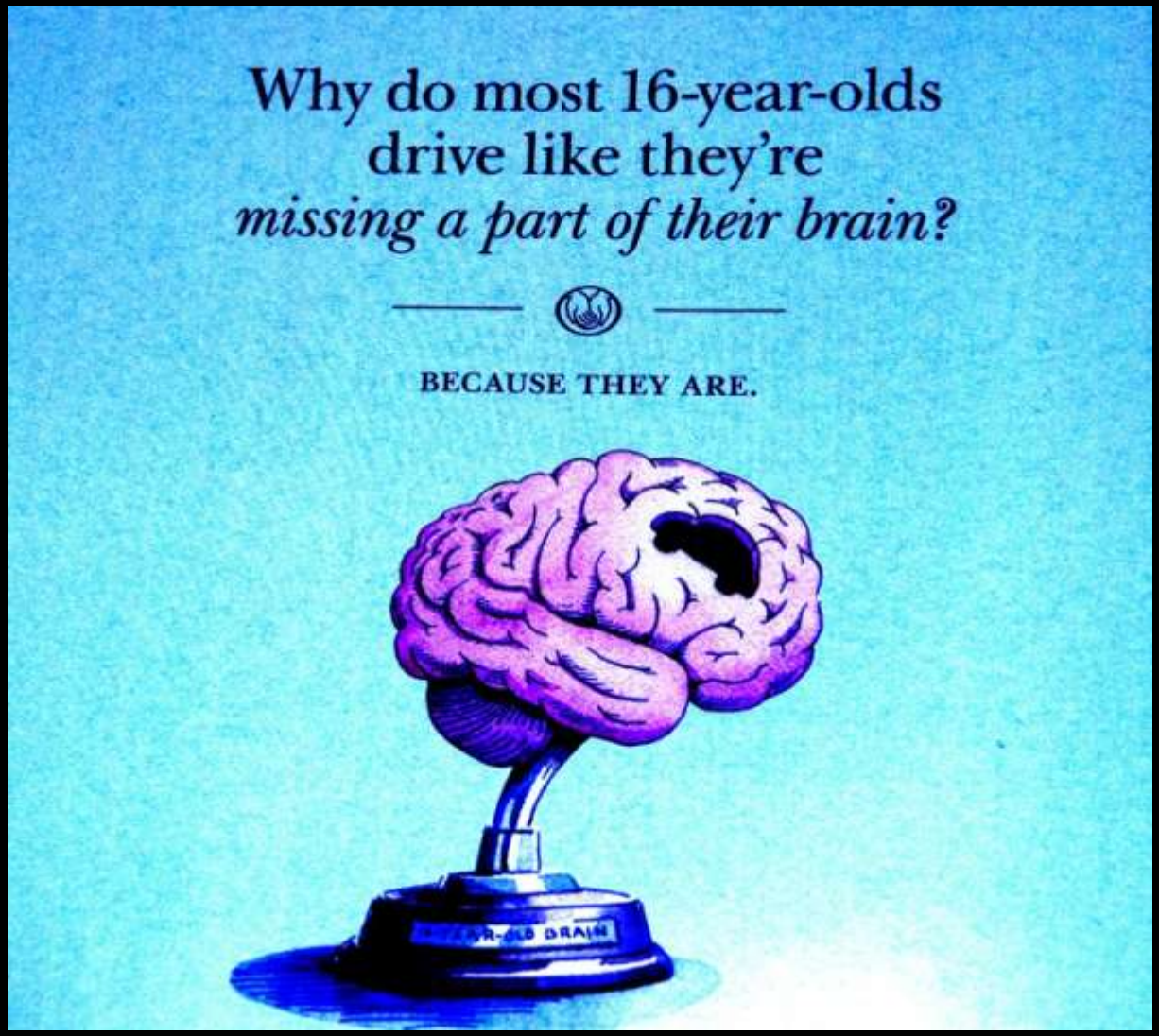
Use it or Lose it



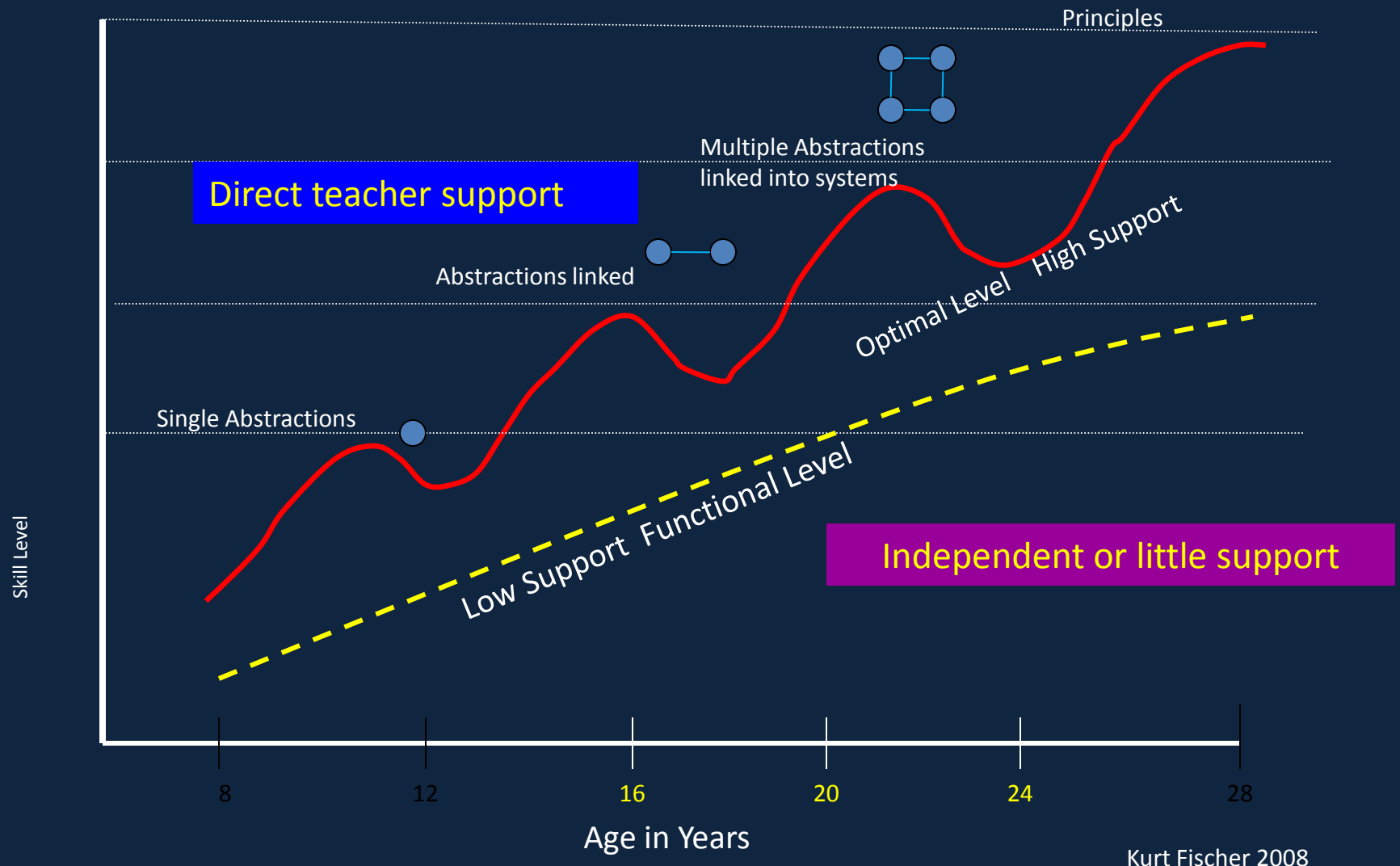
Pruning & Growing Dendritic Spines



Some knowledge about the brain is becoming common



Cycles in Cognitive Development



Kurt Fischer 2008

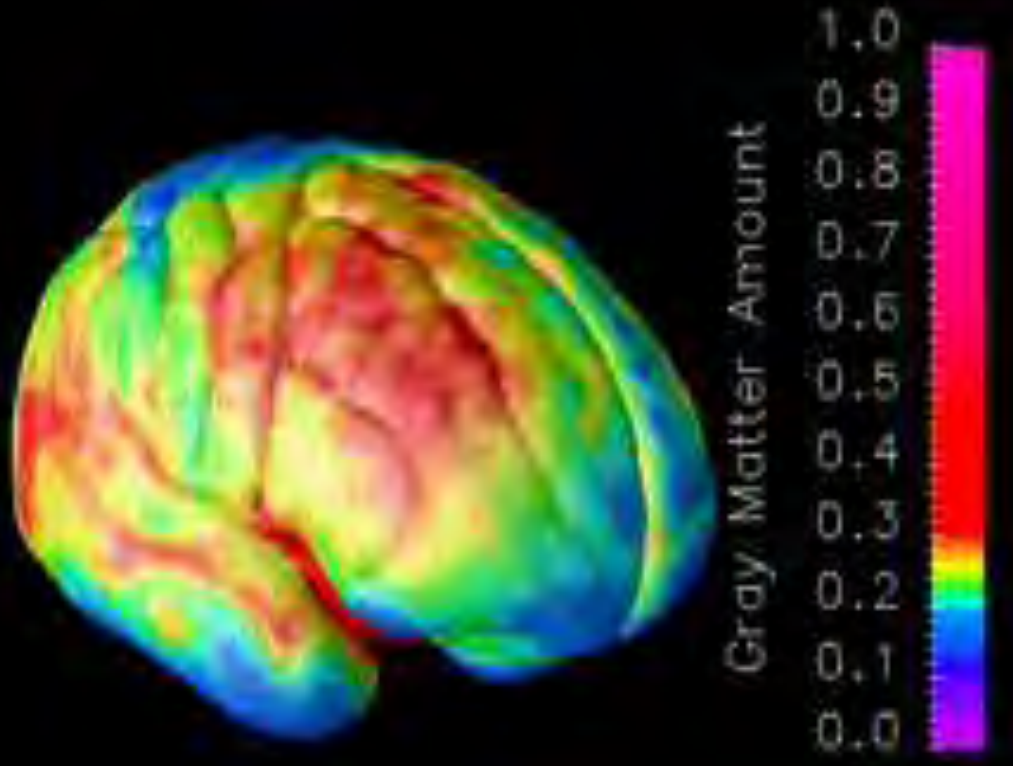
Cycles of Brain Growth

- 3 Cycles during adolescence, NOT STAGES
- 10-12 Years (middle school)
- **14-16 Years (Frosh-Soph)**
- **18-20 Years (Seniors +)**
- Cycles have chaos-fractal patterns

(From K. Fischer, 2000)

Inhibitory Controls Among Last to Mature:

- Implusivity
- Distractibility
- Higher Reasoning-Logic



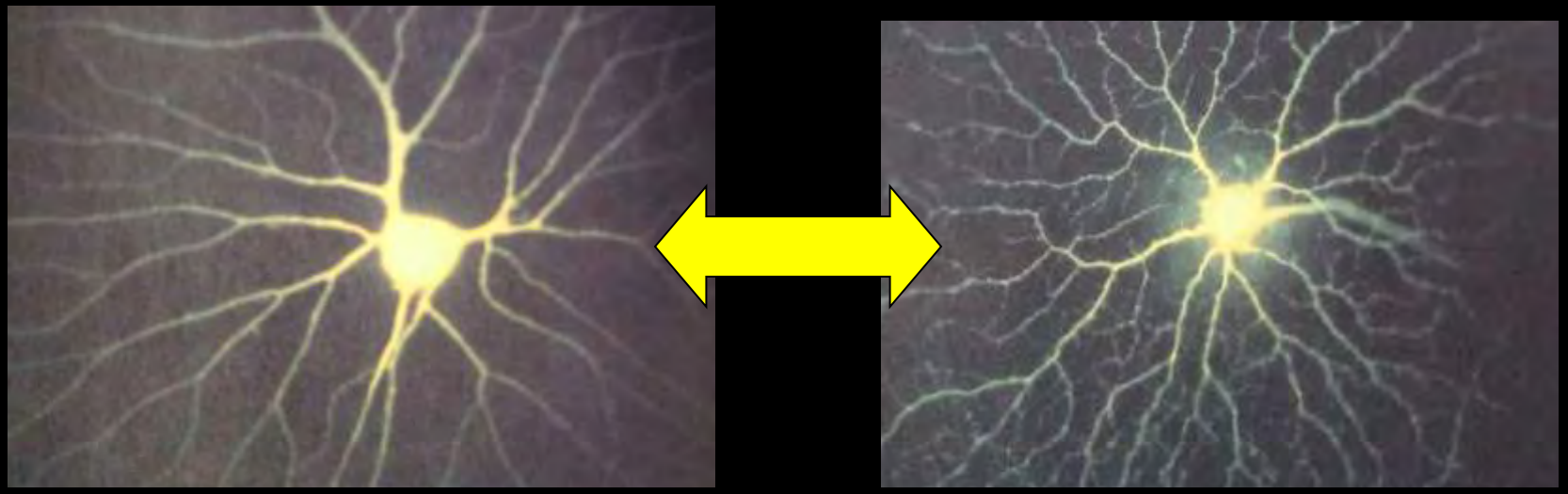
Adolescence:
(not yet fully adult brain)

Age 10-11 to 25/30 years

- Have difficulty recognizing patterns
- Less impulse control
- Less planning/anticipating consequences
- Less emotional control

Skill Acquisition

Use It or Lose It



Under Stimulated Neuron

A neuron that has be “used” or Stimulated

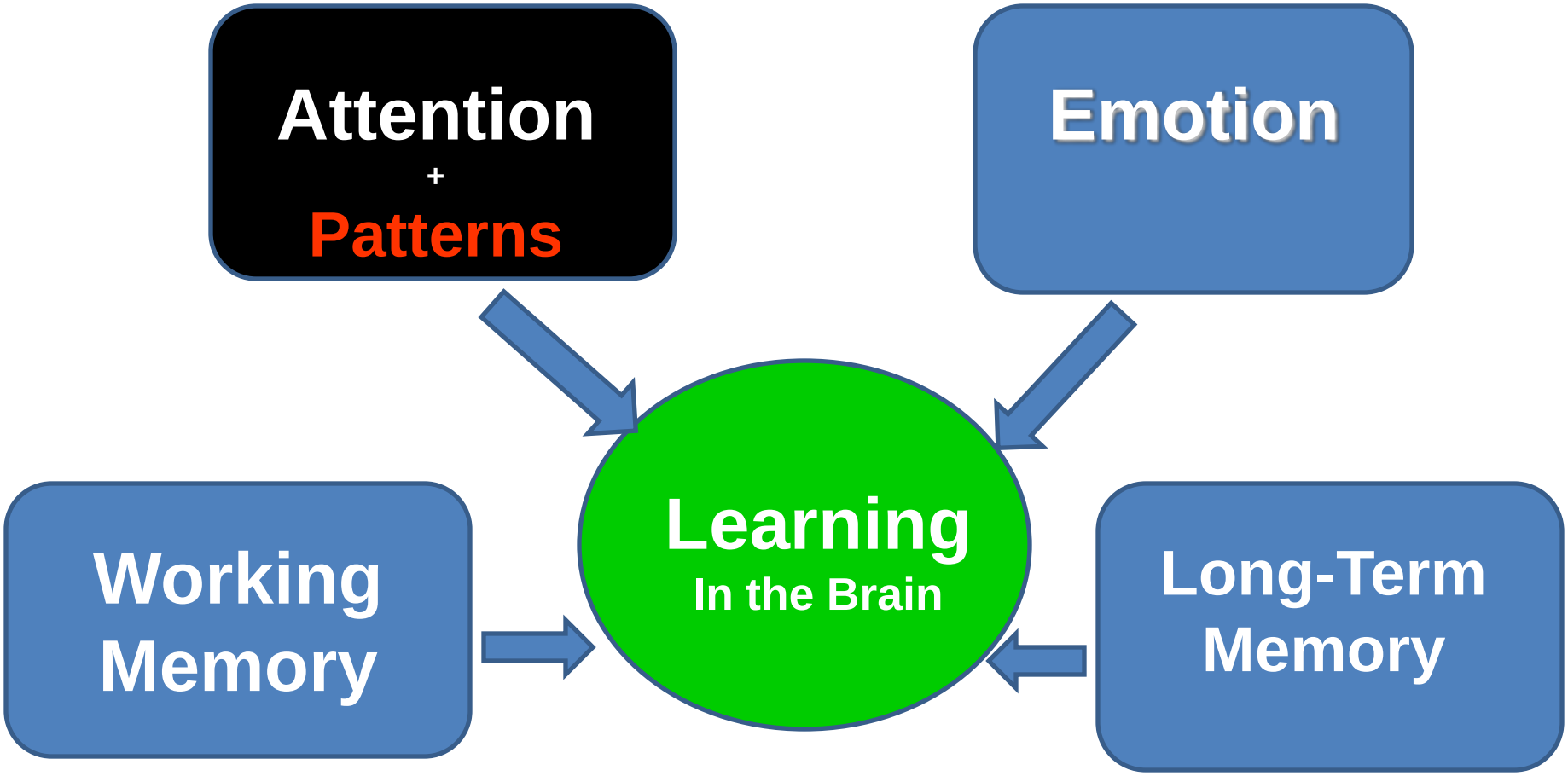
Implications

- Trained teachers elicit higher performances
- Computers aren't able to "read" the person
- No errors = little or no learning
- w/ea new skill, performance initially drops

OLD School

Non-expert trainers (just as patient is not a expert just because they've experienced medicine, a parent is not an expert just because they drive)

Few controlled mistakes?


Attention
+
Patterns
Emotion
Learning
In the Brain
Working Memory
Long-Term Memory

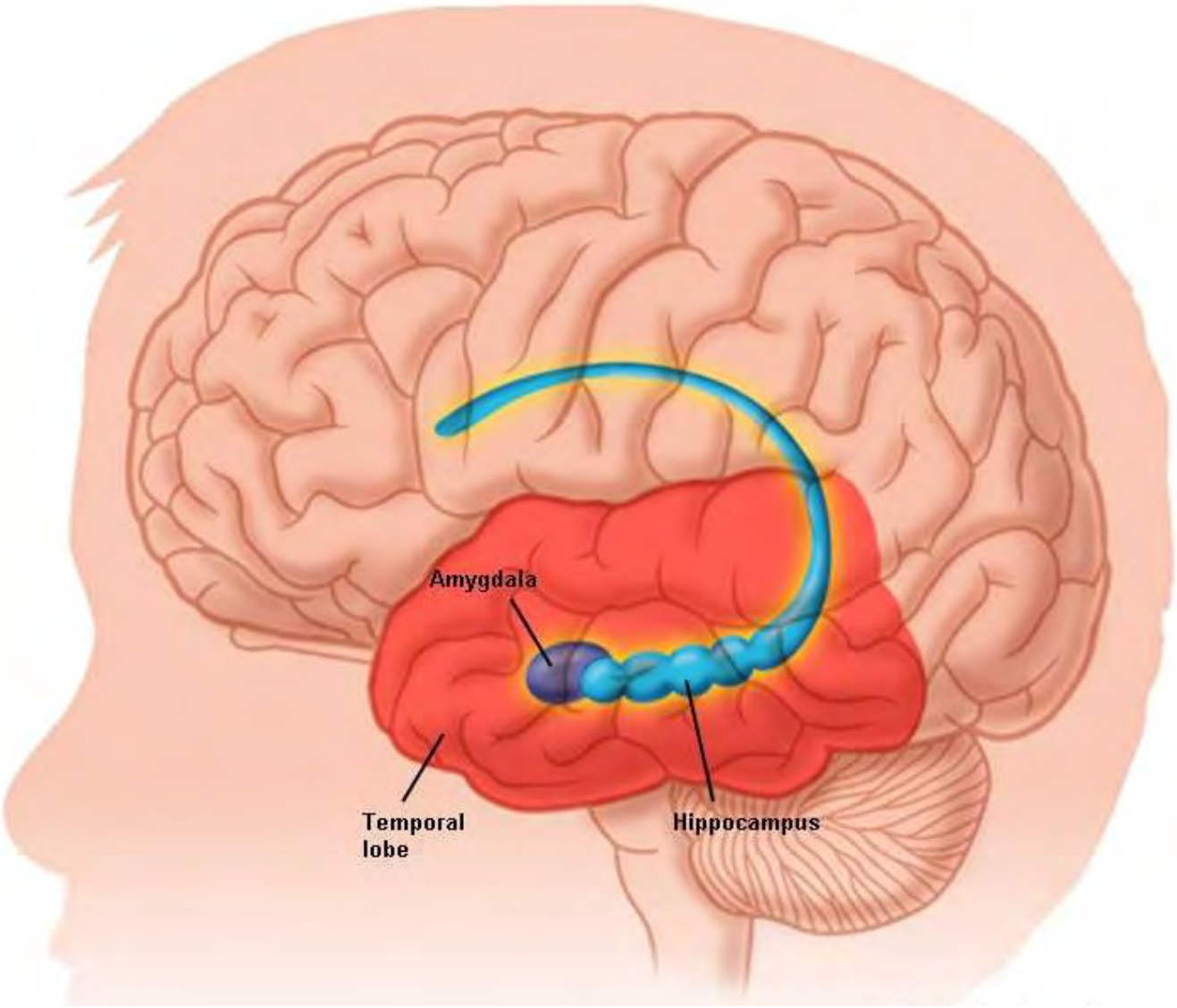
We process information
to find Patterns

Patterns

- Some have Emotional Significance
- Certain Patterns Change our Attention

Patterns → Recognition → Attention

Patterns → Recognition → Attention


Amygdala
Temporal lobe
Hippocampus

Implications

- Students must first recognize patterns
- Brain recognizes ***large*** differences first, then smaller ones…(The snake body easier to spot than head)
- Suggests teaching subtleties ***after*** teaching initial large differences.

OLD School:

- We did not directly and repeatedly work on pattern recognition
- Students became confused trying to recognize small differences

Emotions

- Powerful learning tool
- Experiences are emotion laden
- ***Rarely forgotten when there are personal consequences***

Emotions Affect Learning

If it's emotionally important, the brain pays attention

Incomplete Frontal Lobe Development In A Group

- What happens to judgment?
- What happens to anticipating how *others* will feel?
- What happens to anticipating how *they* will feel?

Implications

- Learning events with high personal ***significance*** are better remembered (High valence and salience)
- Learning events with personal ***consequence*** are better remembered*
- Suggests actual practice (simulated or closed course learning with errors..) better remembered

Old School

We talked, but students did not *experience*

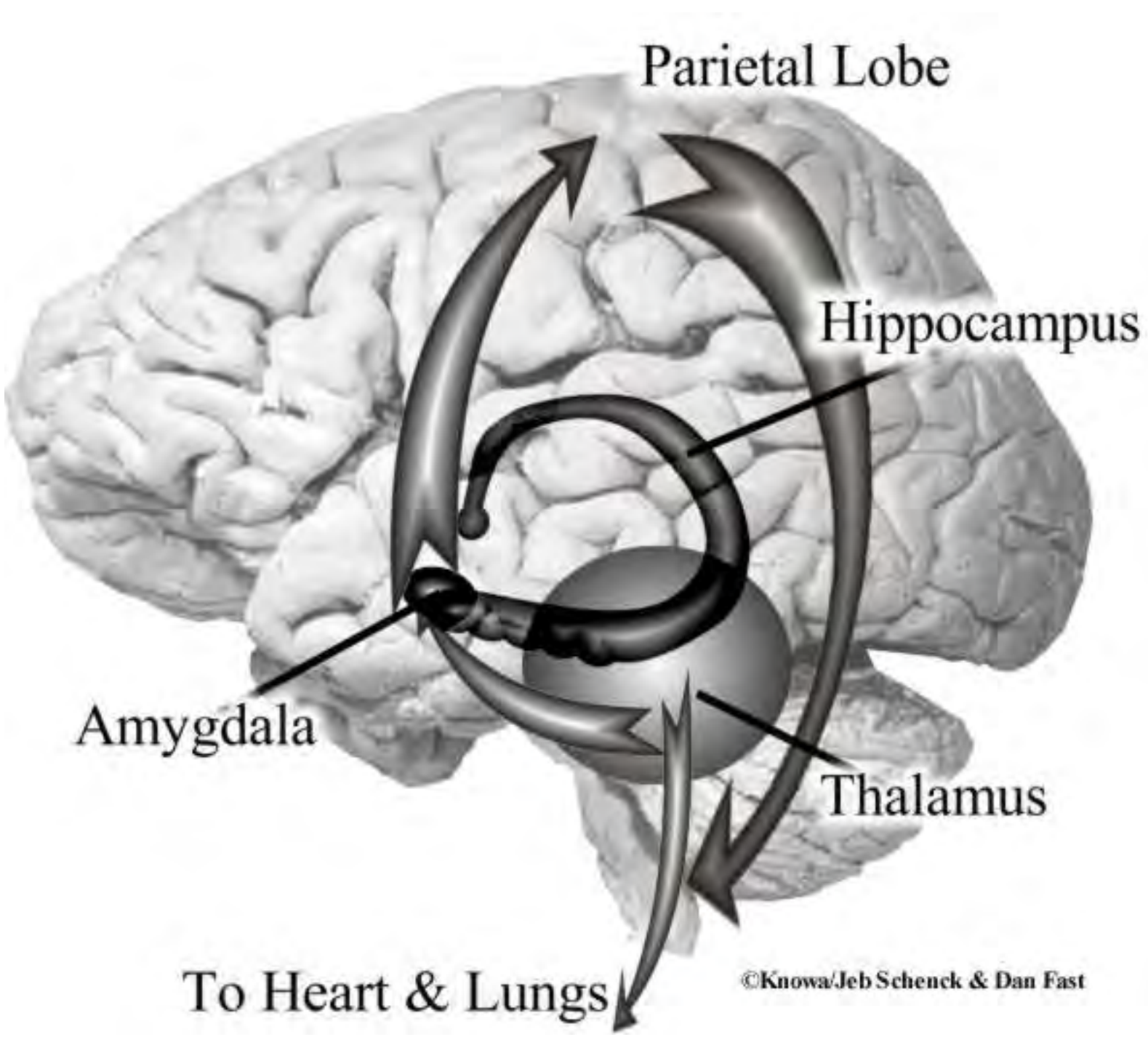
They did not experience significant failure in controlled conditions

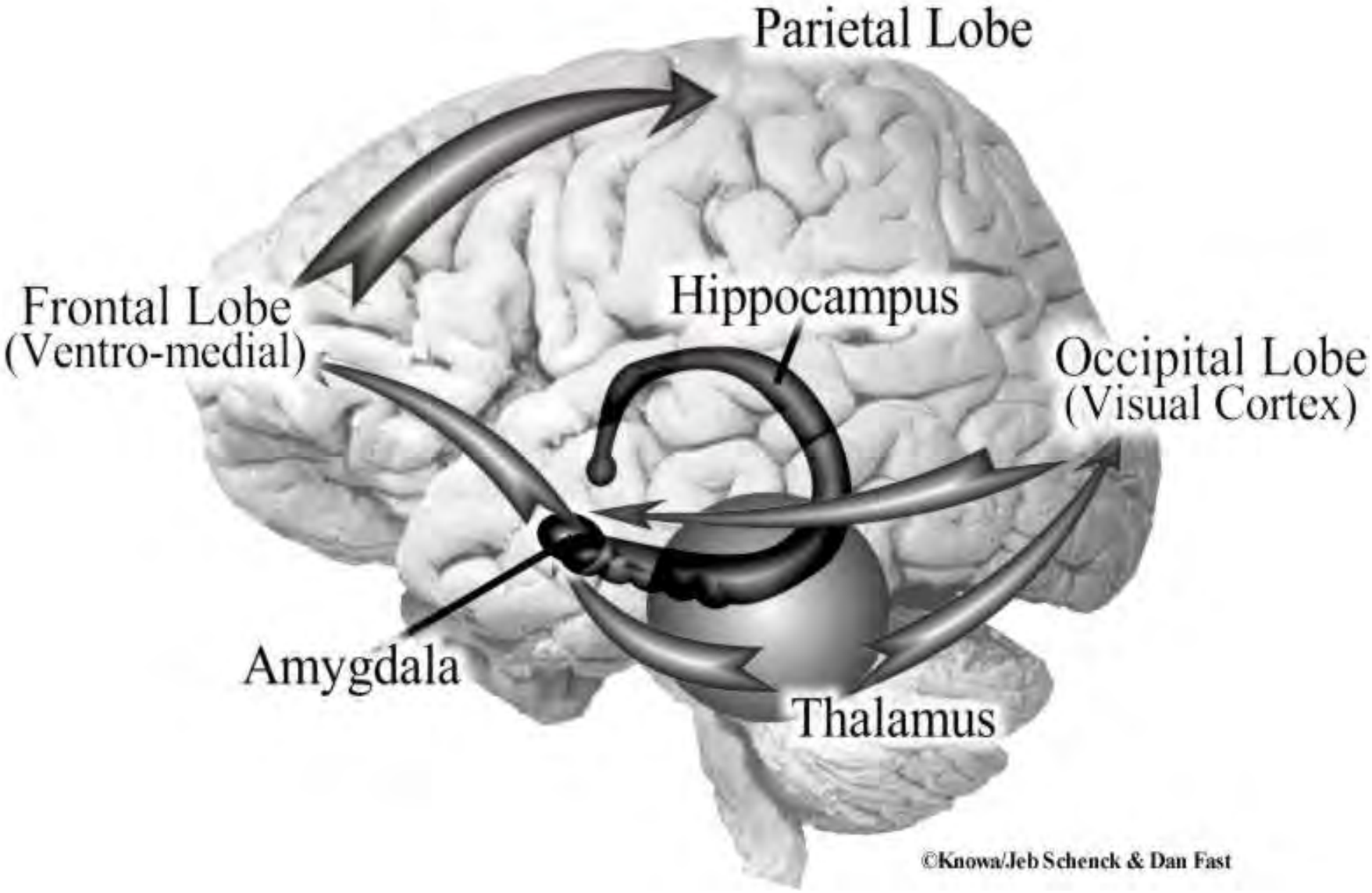
*There is a genetic deficit for about 30% of drivers;
BDNF Val^{66}Met Polymorphism Influences Motor System Function in the Human Brain by **McHughen, Cramer, et al. Cerebral Cortex, 2009,** doi:10.1093/cercor/bhp189

Their Perception Is Their Reality

Perception of threat

affects the ability to THINK & LEARN


Parietal Lobe
Hippocampus
Amygdala
Thalamus
To Heart & Lungs
©Knowa/Jeb Schenck & Dan Fast


Parietal Lobe
Frontal Lobe
(Ventro-medial)
Hippocampus
Occipital Lobe
(Visual Cortex)
Amygdala
Thalamus
©Knowa/Jeb Schenck & Dan Fast

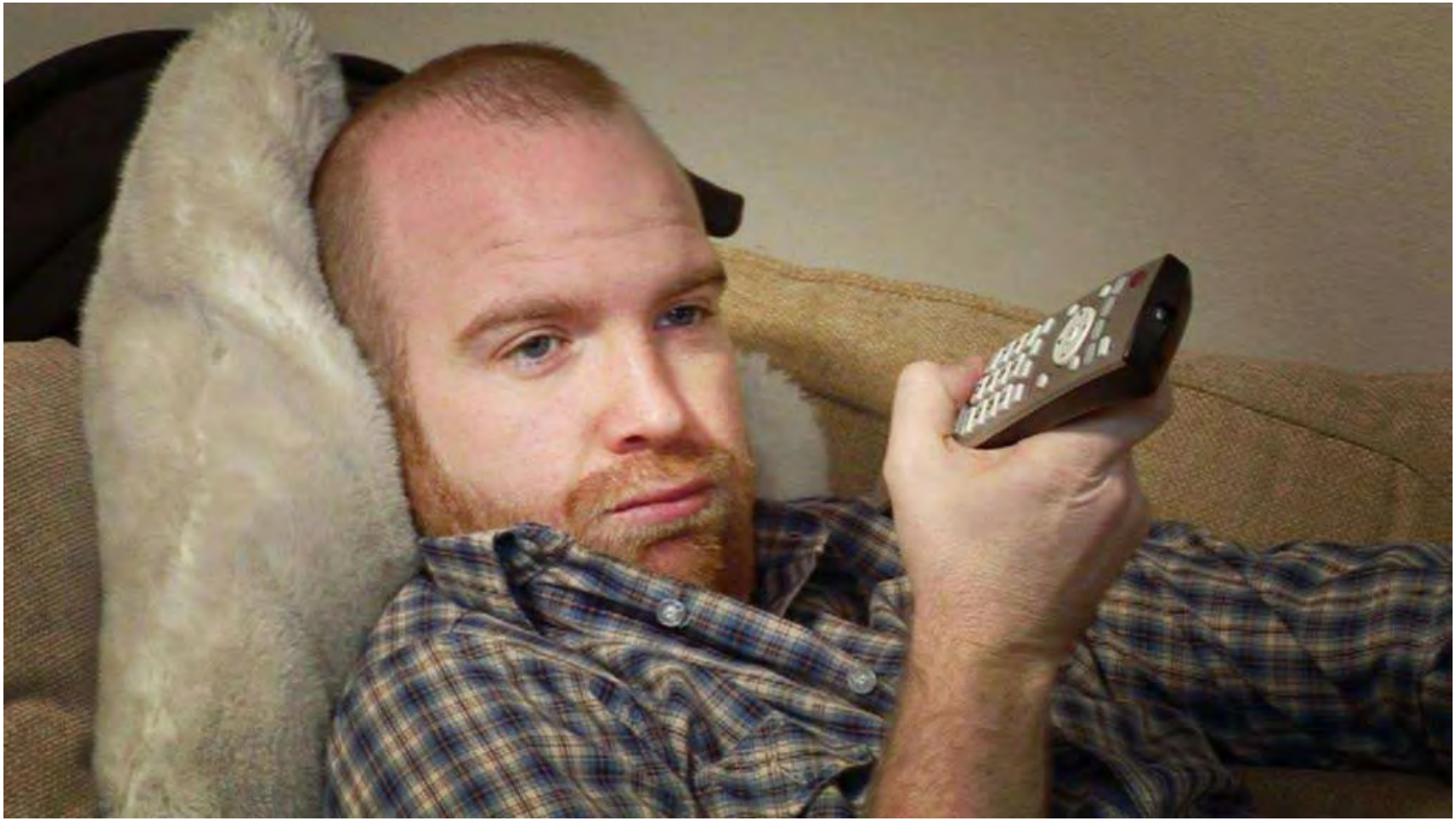
In effect, all animals are under stringent selection pressure to be as stupid as they can get away with.

Richerson & Boyd,

Not By Genes Alone, 2005.

The default state in solving a problem is to do as little as possible.

Brain in default state



Attention

Applied Cognitive Laboratory
University of Utah: David Strayer PI

Attention

- Mirror Systems & Modeling
- Divided Attention
- Limited Capacity (with Working Memory)
- It is NOT a matter of learning styles (EX. visual learner vs. auditory learner is a neuromyth*)

*Pashler, et al 2010 in press

Attention

Multitasking Effectively is a ***Myth***

Divided Attention

- Attention Systems are limited: What is it, Where is it?

A Demonstration:
Attention Interference

- What did you see?
- What happens when there is a distraction?
- What does that suggest about distracting a driver?

Implications

- The brain doesn't multitask (This applies to instruction as well as driving)
- The brain pays attention to modeling (both good & bad)
- Interspersed learning better than blocks of concentrated learning
- Weave between classroom-simulation-field

OLD School

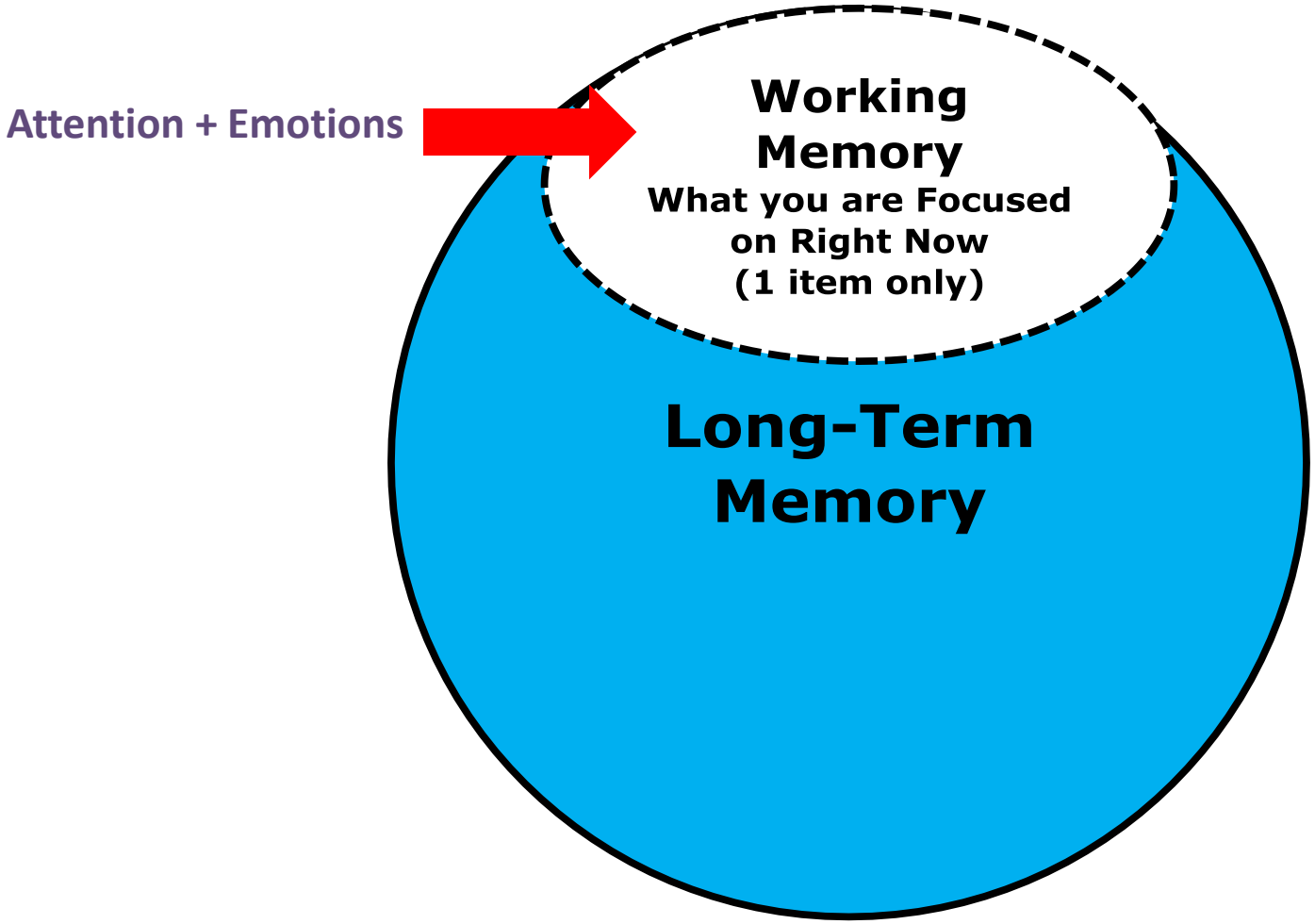
Taking notes & listening

Blocks of classroom-simulation, followed by field experience

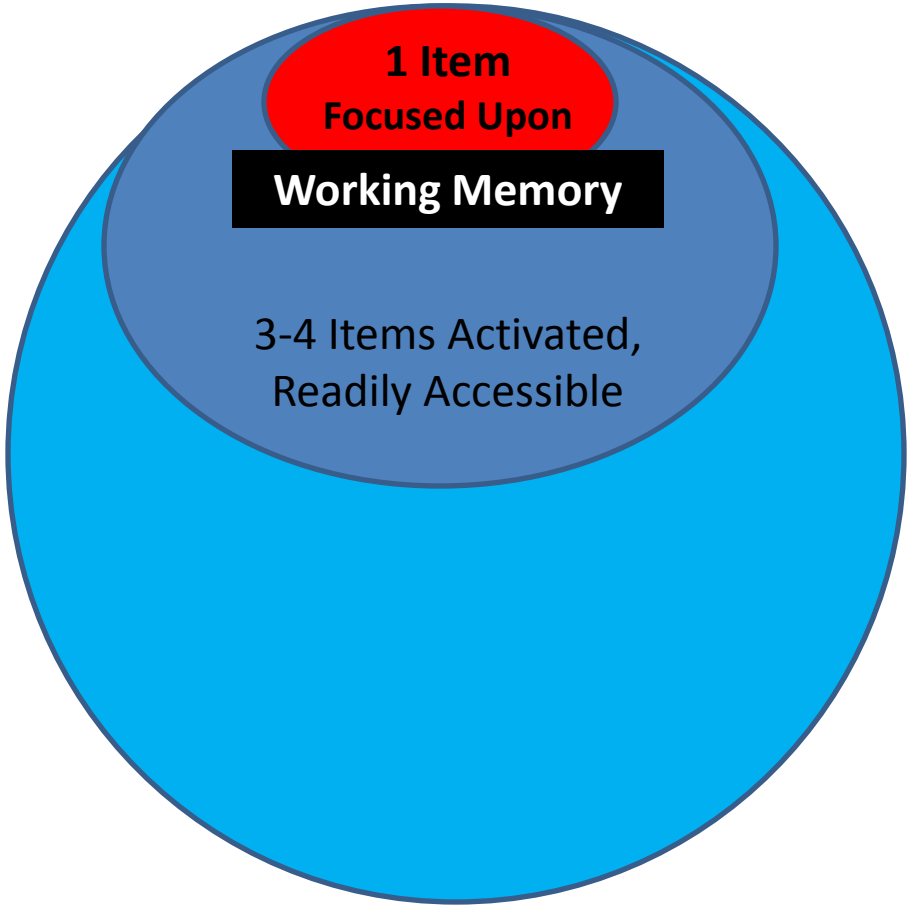
No field experience until well after "lecture"

Working Memory

- It is what your are thinking about RIGHT NOW!


Attention + Emotions
Working Memory
What you are Focused on Right Now
(1 item only)
Long-Term Memory

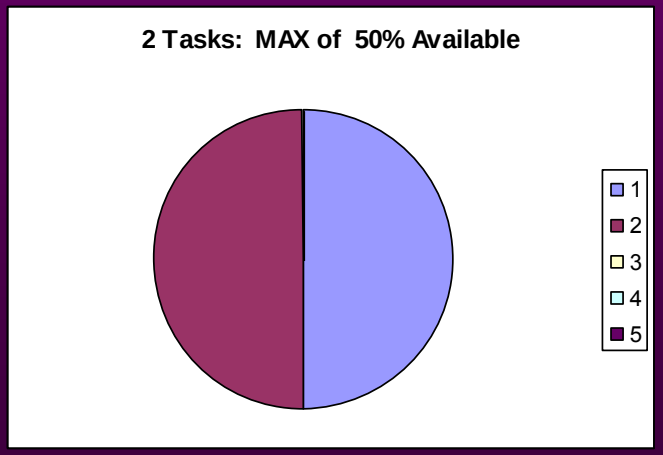
Cowan, 2005


1 Item
Focused Upon
Working Memory
3-4 Items Activated,
Readily Accessible

Mental Reserves

- 1 task 100% max available

- 2 tasks 50% max available for *each* task



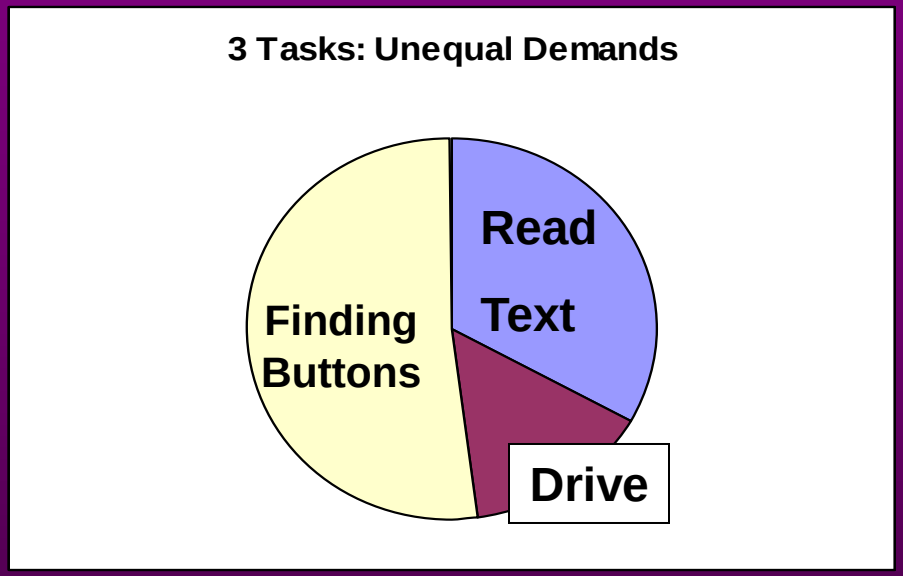
2 Tasks

- Each task needs 1 hemisphere
- 3rd task?

Mental Reserves

- 3 tasks 33% for each?
- Some tasks need more mental reserve, Ex.

  Driving, finding buttons, reading text



3 Tasks

- No hemisphere/brain available
- Performance drops precipitously

Charron & Koechlin, 2010

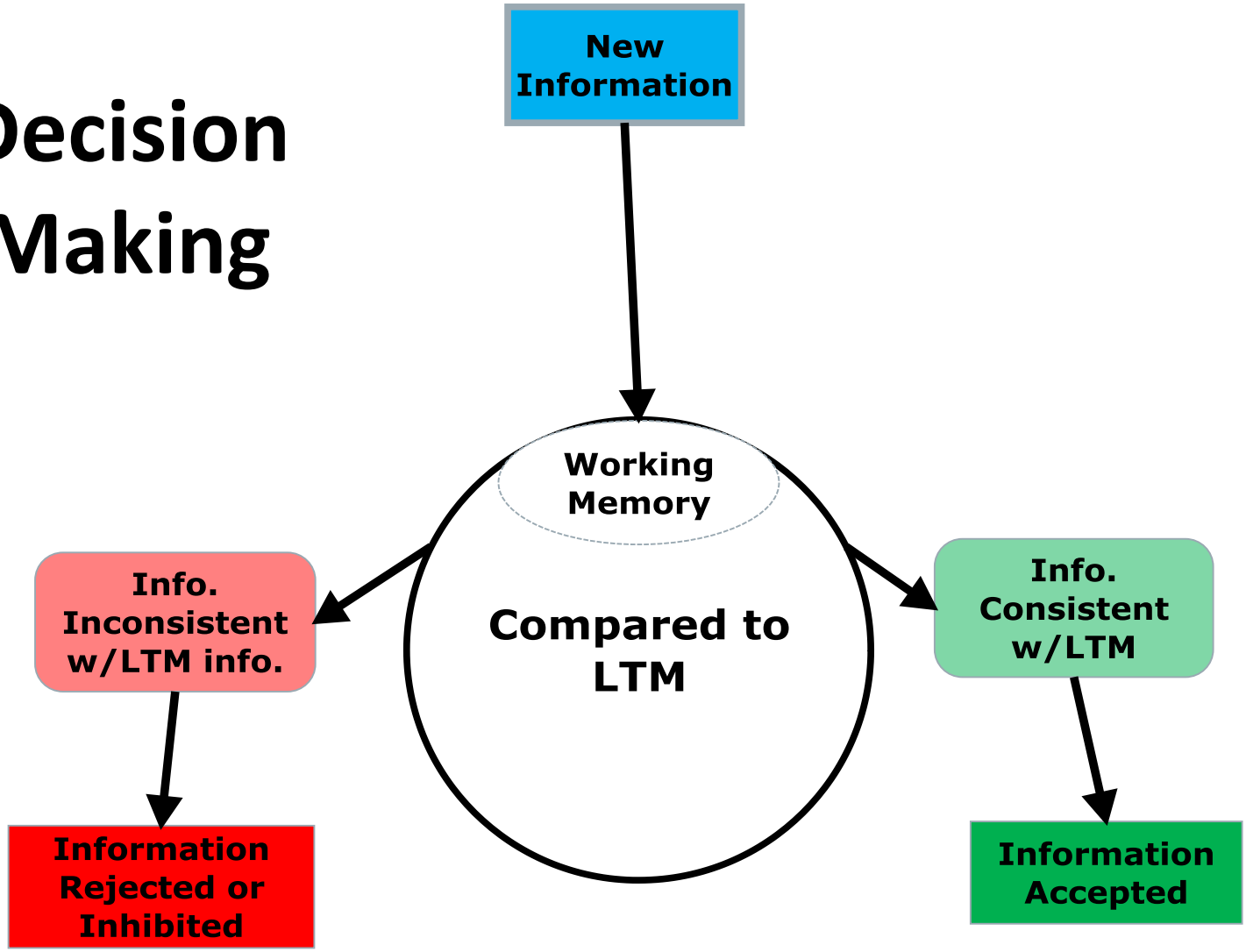
Ophir, Nass, & Wagner, 2009

Decision Making:

Combines

Emotion +Attention +Memory

Decision Making

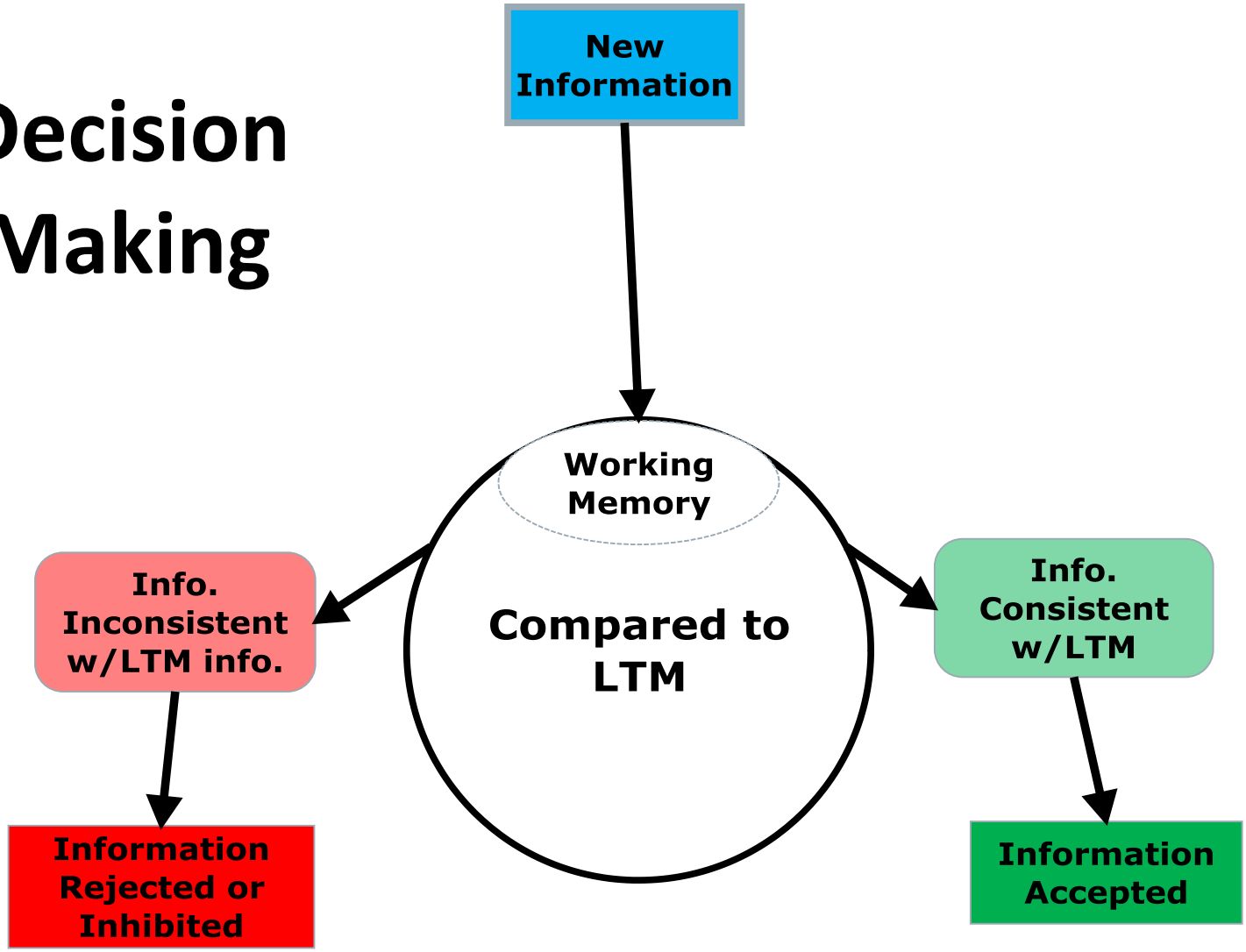


Schenck, 2010, In Press

Decision Making

- We *THINK* we're are making a conscious choice
- But the mind has already decided
- 1st Decision is made non-consciously
- 2nd Then we are consciously "let in on it"
- How do we train for this?
- Train for BOTH non-conscious & conscious levels

Decision Making



Implications

- WM easily overloaded
- WM can be trained to have more information readily available (Cogmeg®)
- Skills moved up to automaticity frees more Working Memory & more Attention Reserves for processing current information
- Genetic deficits interfere, but may possibly be trained around
- Vigilance may last only 10-30 minutes… More accidents?

Old School

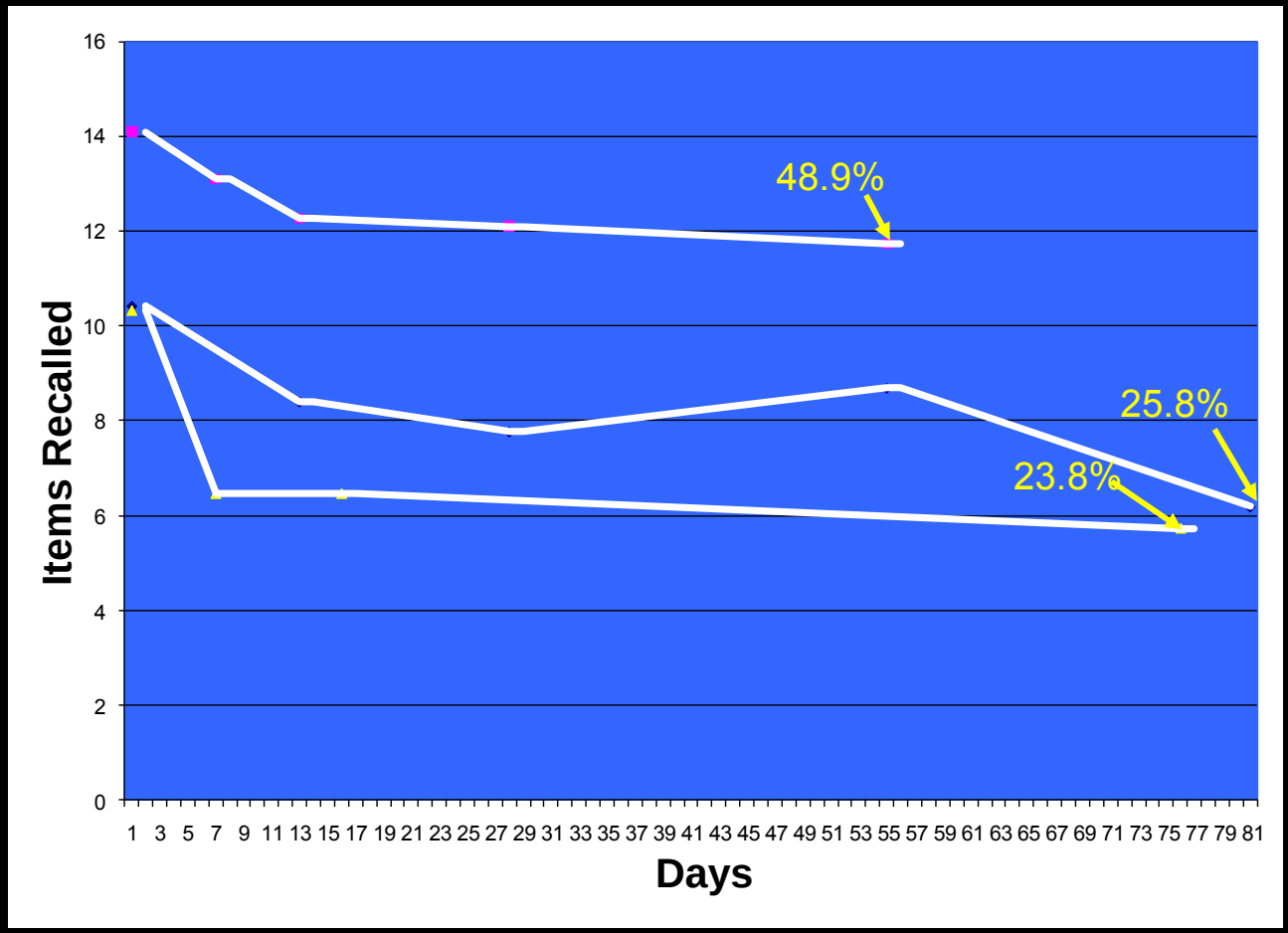
Lots of information, few or no pauses,

Passive initial learning (student is the “receiver” of information)

Students play catch up

Long-Term Memory

Stabilizes in about 10-14 days



Long-Term Memory

- Memory stabilizes after about 10-14 days[1]
- **Distributed Practice Effect**, Practice events further apart are harder, but produce longer lasting memory[2]
- **Test Effect,** Repeated Practice under real conditions is better than only a few real practices.[3]
- Suggests Behind the Wheel in ***subtle-threshold conditions*** can be very important

1. Schenck, J. (2003)
2. Rohrer, D. & Pashler, H. (2007).
3. Roediger, H.L., & Karpicke, J. D. (2006).

Implications

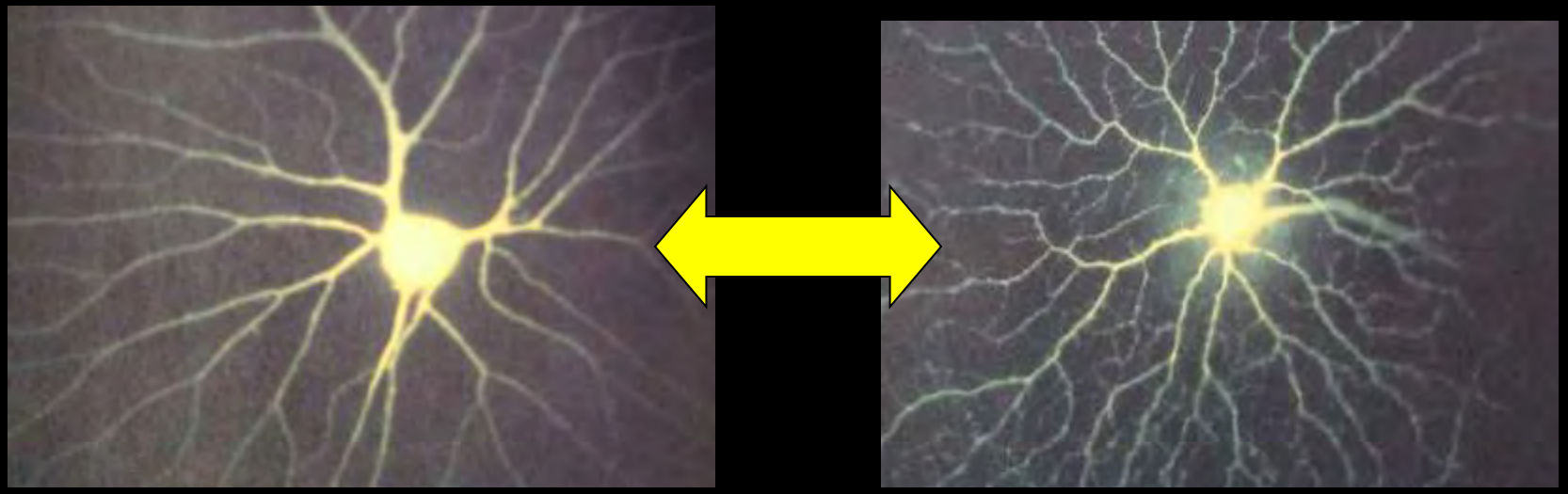
- Experiential learning better remembered than classroom lecture
- Practices/tests spaced
- ACTION + creates BDNF & strong memories

Old School

Testing typically within a day or two of classroom lecture

Assessments lacked authentic/simulated conditions

BDNF (Brain Derived NeuroFactor)
promotes dendrite growth & connections,

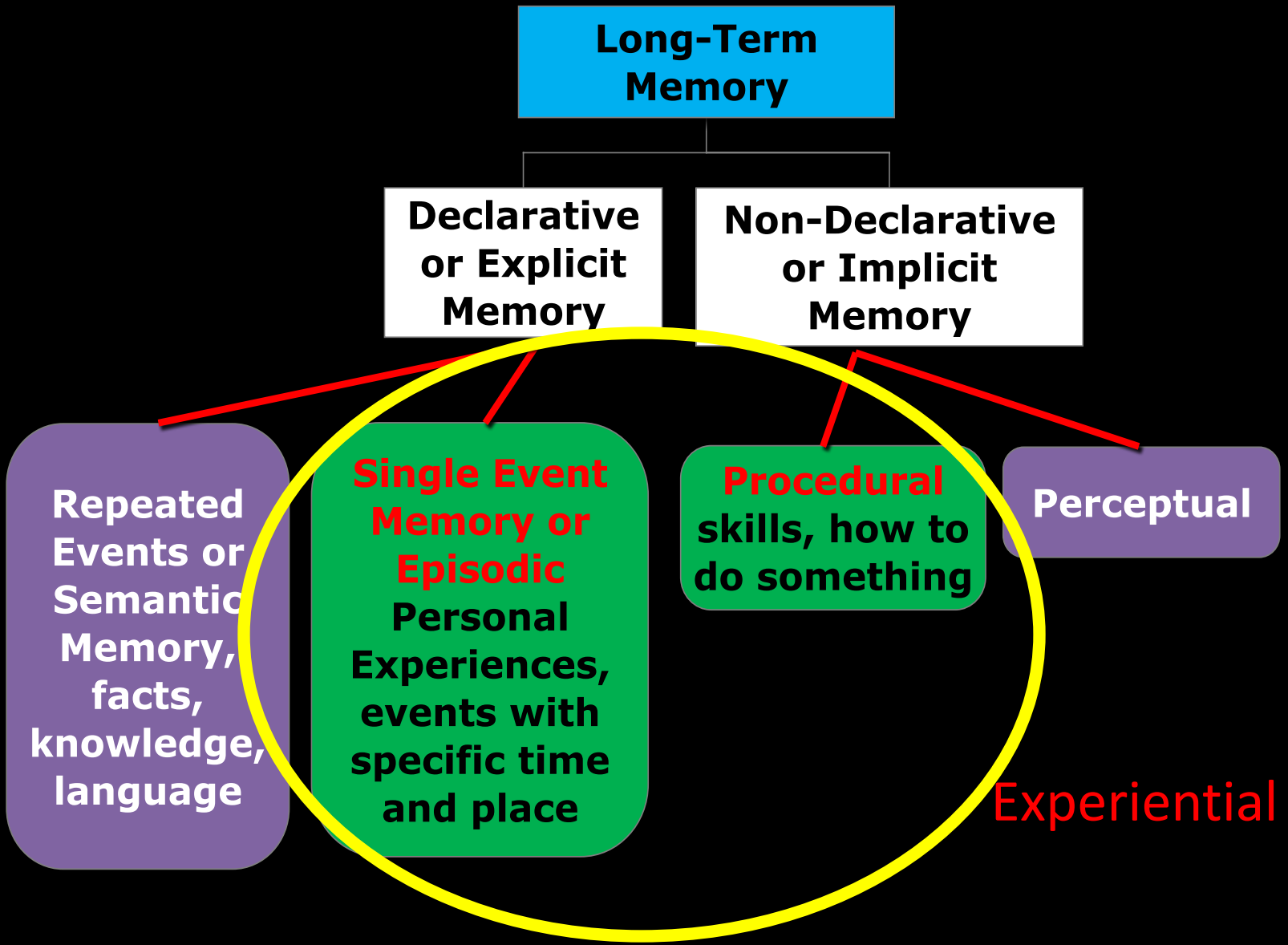


Generated by experience & physical activity

Genetic Issues

- 30% may be have a mutation reduces/prevents traditional experiential learning* (Clearly procedural memories are made—why the difference in procedural memory?)
- Apparently several possible procedural memories
- Alternative training may be needed, possibly different developmental learning curve
- RNA silencing protein? Dopamine role?

* **BDNF Val^{66}Met Polymorphism Influences Motor System Function in the Human Brain** by **McHughen, Cramer, et al. Cerebral Cortex, 2009,** doi:10.1093/cercor/bhp189


Long-Term Memory
Declarative or Explicit Memory
Non-Declarative or Implicit Memory
Repeated Events or Semantic Memory, facts, knowledge, language
Single Event Memory or Episodic
Personal Experiences, events with specific time and place
Procedural
skills, how to do something
Perceptual
Experiential Ed

Considerations

- Trained teachers elicit higher performances
- No errors = little or no learning
- w/ea new skill, performance initially drops
- directly and repeatedly work on pattern recognition
- Students become confused trying to recognize small differences
- Brain recognizes large differences first, then smaller ones…
- Suggests teaching subtleties ***after*** initial large differences.
- Learning events with high personal significance are better remembered (High valence and salience)
- Learning events with personal consequence are better remembered*
- Suggests actual practice (simulated or closed course learning with errors… are better remembered
- The brain doesn't multitask (This applies to instruction as well as driving)
- The brain pays attention to modeling (both good & bad)
- Interspersed learning better than blocks of concentrated learning
- Weave between classroom-simulation-field
- Train for BOTH non-conscious & conscious levels (automaticity)
- WM easily overloaded
- WM can be trained to have more information readily available (Cogmed®)
- Neuroerognomics of attention & vigilance
- Vigilance may be trained? Monitor with Doppler Sonography—TDS Transcranial Doppler Sonography- portable
- Experiential learning better remembered than classroom lecture
- Practices/tests spaced
- ACTION + creates BDNF & strong memories
- 30% with genetic variation reduces experiential learning, possible alternative training needed

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